

THE ECONOMICS OF PURCHASING PRODUCTION MACHINERY.

*Discussion, Birmingham Section, opened by
A. Perry-Keene, M.I.P.E.*

MR. A. PERRY-KEENE: The subject of to-night's discussion is perhaps one of the most abstruse that could be put forward, as the effects will, and do, reverberate throughout the known world. When I examined the title, I calculated that I should like to address you for approximately four hours in enunciating it, another eight in dealing with the local position in England, and another seven in dealing with it from a world or international point of view. Obviously, we cannot do that. Therefore I must short circuit my remarks, but I hope that we can raise enough interest to-night to make the subject sufficiently attractive to take it up at some later date.

To obtain a clear view of the meaning of the title, it is necessary to treat it in the abstract in the first place, but before going on to that, I would like to take you back over, perhaps, five hundred years. At the beginning of that time this kingdom was inhabited by some venturesome people. They were pioneers of the first class, and also, oddly enough, first-rate pirates. We come down through the years and find that the nation acquired potential wealth in the form of precious metals which, after all, can only be used as money tokens on a great scale, but they also retained positive wealth in the form of continents, islands, and other districts, which they forcibly acquired. At that time the population was comparatively sparse.

From that period we can jump across to, say, 1824. Not many of us know that at that particular date something like 24 per cent. of the entire population was on the Poor Law. That was a substitute for the present "dole," but it was very harsh in effect and application. Then came the position when we were called, very truly, the workshop of the world, and at that time, 1830, through the so-called "hungry forties" to 1870, we did without doubt acquire a considerable modicum of wealth. From 1870 to date the population has grown from, say, 28,000,000 to 48,000,000. It is not generally known that for long past the nation has been supported by about 41 per cent. of the population, that is to say, occupied people who

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earn money and pay taxes. If we add wives as occupied persons, we come to a figure approximately 70 per cent.

Now we can review from those facts, the abstract position. There is no known relation, no economic law that defines any proportion as between the number of inhabitants in any area, and the likelihood of paid-for employment. That is a fact which is very largely forgotten, and that will reflect itself presently in the question of purchasing production machinery.

Dealing with this abstract position we ask, "What is wealth ?" "What is trade ?" "What is money ?" None of us seem to be really sure. The Lord of Nature presents us with entirely free gifts in the shape of minerals in the earth, heat in the form of sunshine, and so forth ; they are free, no charge whatever. Wealth is built up and maintained entirely by the service of the brain or brawn, or both, which one man can give to another, or one nation to another. We create wealth solely through the agency of time and energy applied to such free gifts through the human element, but there are two courses open to that time-energy, creating either a good cost or a bad cost.

For example, imagine we require for our work iron or copper ore from the earth. We proceed to dig it, and add three or four increments of cost, where, if we had been more alive to the job, one only would have been added. We have, perhaps, to transport it. We do the same again—add three where we ought to add one. We build up the commodity, which we endeavour to sell, and then find we have a cost having four or six points against it instead of two. That produces the well-known phenomena, plenty of goods, but unsaleable, for a very succinct reason. Man lives by exchanging his services with those of other men, but it is obviously necessary that any one service shall contain the same intrinsic value as the service with which it seeks to exchange.

That brings us to what we call trade. Trade is the exchange of services, and we must obviously exchange equal values, otherwise failure ensues. Money follows this service as a token of work done, and it is this sequence that should be appreciated by all of us. If we observe the development of the human race we find that it first occupied the whole of its time in looking for food and obtaining shelter. The man of ten thousand years ago was hard put to it to live. He had to hunt all day, and rest at night in whatever shelter he could come across. Evolution showed where we differed entirely from, for instance, the monkey. We began to develop and go forward, as by applying thought we were able to obtain our food and shelter in shorter hours. Finally, we come to the position where trade arose. Men had spare time in which they could serve other men, and from that we gradually evolved certain money

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systems (about the time of the Phoenicians) seven thousand years ago.

It was difficult to exchange goods for, say, pigs or something of that sort ; it was inconvenient to cart them about, so we evolved money. It is very necessary to remember, when discussing this particular subject, that money is purely the handmaiden and very much the humble captive of man's effort or "time-energy."

Reverting for a moment to that 70 per cent. item which I mentioned just now, from the fact that 28,000,000 people were here in 1870 and 48,000,000 now, a simple sum in proportion will show that if we had kept to our 41 per cent. or 70 per cent. ratio of employment, 14,000,000 people in this kingdom would quite automatically be out of a job. It is at this point that we can begin to consider the title of the address.

The present unemployment factor is something in the neighbourhood of two and a half millions. Modern economics I think, had driven some of those people off the market ; some of them could never be employed owing to advance in the technique of production. Such being the case we see that the—in some instances—despised machine is, in fact, very much the friend of mankind. It has obviously absorbed the odd millions, the difference between 14 and 2½, and it has done something else. I have the advantage in age over some of you, and can quite clearly remember in my youth the hours that we worked, and the remuneration that was paid to labour and executives. Only the other day I was reading a memorandum written in 1884 by a man who is one of the foremost bankers in London. He walked from the north side of Glasgow, duly arrived in London, and was only too glad to accept a remuneration of £10 per year, paid quarterly at the rate of £2 10s. 0d. I recollect the seventy-two-hour week—retiring into the sixties, then into the fifties, and now into the forties.

Wealth, or the standard of living, can only be maintained under the conditions that we have evolved, by making more and more exchangeable entities. Hence we see the extreme fallacy of such advice as "proceed at the speed of the slowest." That is another way of saying "you will get the least money it is possible to pay."

Men are in the main alike. If we put forward proper incentives, there is no doubt they will respond. In 1922 the company which I have the honour to serve put a car on the market at about £860. That car sold with some difficulty. Recognising the true economics of the case, we reduced the price to £270, and the effect was most remarkable. We were bombarded with orders. Instead of driving sales, we had rather to allocate them, and to date we have sold something in the neighbourhood of £32,000,000 worth of that particular vehicle. The reason is fairly plain. If we take the strata

of emoluments paid in England, and convert them into a diagram, there is found at the base a large block of people with comparatively small incomes. Then advancing in step form, greater incomes, and at the top a decreasing cone.

Segregate these figures, and we find the amazing fact that the combined purchasing money of the people in the top portion (we will call them the "nabobs") is in the order of 77 millions, but the combined purchasing power of the lowest portion (whom we will call the "costermongers") is over ten times that figure, in the neighbourhood of 800,000,000. That is one of the facts that has been recognised by Marks & Spencer's and Woolworth's, and it accounts for the gigantic profit that these undertakings make. These are merely an accumulation of tiny profits on each deal.

One of the problems that arose when we reduced our car from £860 to £270 was this. It was necessary to alter the time of an operation. Where a man was originally getting 72d. for a job, we asked him to accept 4½d. At 72d. or 6s. that man earned £1 14s. 2d. By reducing the price of the car, our market, which used to be in the upper strata of the diagram, was now a far larger one, which multiplied the sales by thirty or forty, and here is an apparent paradox. The man who earned £1 14s. 2d. under the first conditions under the new ones earned £4 8s. 4d. That is a direct instance of the fact I mentioned just now. That man was subconsciously creating per minute or per period more saleable entities at an exchange value that was correct; it would exchange with other commodities in the world, therefore it enabled him to put out more total "time-energy" and so to enlarge his emoluments something like three times. That sort of fundamental truth bears out and justifies a full, frank, and free discussion on the economics of purchasing production machinery.

The world is entirely dependent for its trade upon quantities of exchanged services. Here—again from practice, is a curious fact. My company sell one ton of motor cars at almost exactly the price of one ton of farm turkeys. That is a measure of equitable exchange.

It is obvious that none of us have ever purchased all we would wish, for one reason only—the price of everything has been too high. The world finds itself in an extraordinary position. There are on the earth 2,200,000,000 people, but we white men have so far only catered for approximately 700,000,000 out of all the world's markets. We can easily appreciate the fact that the world's markets are in themselves infinite. From that fact we can also appreciate that, with a sufficiency of proper production machinery, we could go some way towards meeting the real demand, if the cost were right.

We find ourselves in a position where the engineer has evolved

STRATA OF EXCHANGE (PERSONS)

Yearly Income	Persons
£1500-£2000	44,000
£1000-£1500	98,000
£800-£1200	86,000
£600-£800	135,000
£400-£600	288,000
£200- £400	1,535,000

RISING BY
£200 TO
£2000

£160/£200-2,031,000

£130/£160-3,490,000

£130 & LESS
11,250,000

systems that have, in effect and in practice, almost brought into sight a millenium of production. We have to a large degree removed the curse of Adam. We are, without question, dealing with our monetary system and our accounting in Phoenician terms. The Phoenicians had excellent book-keeping methods : it was done on blocks of clay and was nearly everlasting. We have substituted paper, but at present we are not too far ahead of them. Now we can apply that directly to the subject of this discussion.

Without question, after forty-five years' practice as an accountant, engineer, and actuary, I would say every time, give us more machinery, but I would visualise this. In our children's time, or the next generation forward, there is no reason why, if we use sufficient machinery, we should not have far more "unemployment" than we have got to-day—this is what we want ! We are getting unemployment because we are improving methods of production, but we do not as yet know what to do with surplus time. We call it a curse : it is a blessing in disguise ! The curse of Adam can be removed to this extent : there is no reason why we should work more than four hours a day. Nature has divided humanity into clearly marked types : worse than that, it has divided it into colours and sub-colours, into clear cut languages, and not content with this, has divided these languages into local dialects. Then we have extremes of temperament to deal with. These are difficulties that have to be pushed aside and got out of the way before we can fully deal with this question of production machinery.

Machines can be, without question, the friend of man. They can produce any quantity of entities that are likely to be required by him, but this means that we must evolve, perhaps forcibly, an entirely different monetary view, both as to practice and effect. There will have to be some correlation between quantity production, and consumer. We have pursued for thousands of years without much change a policy of cartelism—that is to run on a shortage list—to try and keep prices high by a short supply. The engineer has unconsciously upset this policy. He has, in a short hundred years, raised production possibilities so that, on average, a man to-day can produce 30 to 34 times as much as his forerunner of 1834.

There is another bogey. We have no system of really cheap distribution. The other day I had an indignant letter from the Australian Bush. Here is a sample of distribution. A certain article we make costs us 8s. We sell it for less than a sovereign. This man sent me a copy of an invoice in which he was charged £16 8s. for this part ! It is perfectly obvious to all of us that the moment we send a new part from the works, from that moment it must begin to depreciate automatically. Yet at the end of that journey a £1 article costs £16 8s. 0d. Under such conditions as

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that we obviously cannot get as far as we would like. It must hold us back.

You may say: "That has nothing to do with production engineers." Well, hasn't it? It has, directly and indirectly, but that would take me many hours to explain. It does bring us back again to the question. What is the true technique of production? Understanding must begin in the abstract with a clear view of the fact that potential wealth and our standard of living must very largely come from the hands of the production engineer to-day. It is dependent absolutely on the correct method of transforming the efforts of the human element—which I call "time energy"—into saleable entities.

On the concrete side you then come to various ranges of machines. You have to consider the types of humanity that are capable of operating those machines. You will have to study the correct technique, psychology, ethics, sociology, and all the elements whereby we shall in time almost entirely remove what we call the curse of Adam—really hard labour.

We shall in future organise ourselves so that we do not make a thing twice when it is only wanted once. There is nothing to guard us against that at present. We find this sort of absurdity to-day: engineers being called upon to erect a factory for candlesticks, and another lot of engineers a factory to make motor-cars. The candlestick undertaking does not make very much profit, so you will find this impossible condition—its capital tends to drift into the more prosperous motor-car concern, thus adding to the confusion. We are put in the position that we cannot make suitable exchanges which are the foundation of trade.

That is one of the troubles we have to face in the future. I think that a body such as the Institution of Production Engineers can become one of the greatest national assets, but only if it will, by evolution of new thought, study these facts which I have had to describe so shortly, and in the light of them evolve systems which will take us further along the line of prosperity.

MR. A. L. TAYLOR: Mr. Perry-Keene has put my thoughts into directions that, I must admit, have confused me. His knowledge of the subject is evidently a very deep and very long one. He has taken it from a standpoint that probably is new to many of us. From my point of view, the question of the purchase of production machinery resolves itself into the best type of machine for a particular job under consideration: whether it shall be of the multiple type or of the single type. Also the question of the feeds and speeds enters into that aspect of the situation, and in many ways the personnel and operators. That is rather a serious aspect of the situation.

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Twenty or twenty-five years ago one had male operators inevitably. To-day, one finds female operators. That, to a very large extent, has caused designers of machinery to bring forward designs that are more or less fool-proof. From that point of view, less skill is required to operate them, and the natural result is a reduction in operative costs.

Another aspect to-day is that the machine-tool salesman has his point of view and puts forth certain ideas. It may be that those ideas are compared one with another with the object of selecting the best type of machine as it appeals for your production. Further, there is the aspect of maintenance. We have found particularly that, with the type of operator that one has to-day, the maintenance side is rather a serious factor. A machine may have automatic lubrication, or it may not. We have found that the question is rather a serious one from the point of view that it is possible to have a very expensive machine and use it with negligence, and in a very short time it is in rather a bad way. The situation has arisen whereby it is, to-day, necessary to have supervisors with the object of coaching operators and others from that point of view.

MR. R. C. FENTON : I am concerned with the selling of production machinery and my remarks are made more from the point of view of the seller than of the purchaser, and one cannot help noticing the entirely different psychology which influences purchasers and sellers. I think that it would serve a useful purpose to consider why production machinery is purchased. One can definitely classify purchases somewhat as follows : To increase the existing output ; to take care of an entirely new product ; to improve the product ; to replace existing machinery which has reached the end of its economic life ; pride in having the best equipment.

One of the fundamental points to be considered is whether new machinery shall be in line with the existing, or branch out into a new type, discarding the old. This question must be looked at from a logical point of view. I have in a number of instances been surprised to find that new machines have been put in and the same piece-work price paid as on the older type of machine, notwithstanding the fact that the new machines are capable of giving at least 50 per cent. more output. If the old machines had been disposed of and their value offset against the purchase price of new plant, the capital outlay would not have been greatly increased, but the whole production would have been on the same basis and new piece-work prices could have been fixed with what would have shown a considerable margin in production cost in favour of the purchaser. And again, under this heading, I think one can also consider the question of the sequence of operations because it is my experience that if, for example, the capstan lathe department is overcrowded and a new machine or machines are installed regardless

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of future operations, that in a short time the "bottle-neck" is only transferred further along the line. Therefore it is necessary to face the whole problem at once, rather than bolster up one department which will lead to overcrowding in another. I know that the everlasting question of cost is a determining factor with many people but to my mind the problem must be faced with courage, if the full value of production machinery is to be obtained.

Another point which has often struck me very forcibly is that when considering a new machine, so much attention is given to the occasional production rather than purchase the most efficient machine for the major portion of the production. Obviously the greatest savings are to be made on the greatest proportion of the work and if the small quantity odd job is to be allowed to dominate the decision, the general efficiency is lowered. This may seem a foolish point to you but as a salesman I have encountered it so many times that I feel it is worth mentioning.

Where an entirely new product is concerned the problem is usually somewhat easier, as the whole line can be laid out in proper sequence. I do not propose to suggest methods to you of arriving at the most economical plant to purchase, preferring to leave that to the suggestions of other speakers, but this point I would like to emphasize—that it is unreasonable to base estimates of capital extinction on all classes of machines for the same length of time. I am of the opinion that special machines should be treated as a class to themselves, and that standard machines should be given a reasonable economic life. I have, in many cases, met people who expect to extinguish the capital cost of a capstan lathe for instance, in the same time as a special multi-spindle drilling machine, and I submit that this is not economical because the special drilling machine is only for use for the particular job for which it is designed, whereas the capstan lathe can be retooled to suit a wide range of productions. I agree that special tool equipment, fixtures, etc., should be treated separately, but the machine cost itself, I think, should be based on the standard depreciation allowed by the shop.

To improve the product, one must give careful consideration to the nature of the machinery purchased. The question of depreciation, to my mind, enters largely into this subject, as it is presumed the improvement in the product must be kept up over a considerable period and obviously the quality of the product and the quality of the machine which produces it, are to some extent linked together. As a seller, I have often heard remarks made that the machine was quite satisfactory when new but due to wear and tear, they are now having difficulty in producing work to the required accuracy, and it has crossed my mind that the purchaser did not use very much discretion when purchasing originally. One has only got to compare the price range on many classes of machines to see the vast difference

between the highest and the lowest grade and it is unreasonable to expect machines in the latter category to maintain their accuracy as long as the more highly priced article.

The question of replacing machinery that has reached the end of its economic life is, to my mind, one that is considerably neglected. There are many owners of motor-cars who consistently change their cars every year or two years, trading in the old car for a new one, but if you suggest to them that they should treat their production machinery in the same way, they are horrified. Why should they be? All said and done, their production machinery is subject to an enormous amount of wear and tear, and if run to destruction, it is worth very little more than scrap metal, whereas if at the end of a reasonable period, it was traded in for a new machine, the shop equipment would be kept at a high standard and at the same time the maker of the machine would be able to recondition it and sell again to those people who are prepared to buy such machines. There is no doubt at all to my mind, that many factories suffer very seriously from the lack of an organised replacement scheme. They depreciate their plant for income tax purposes to the maximum allowed by law, but they do not spend the depreciation money in keeping their plant up to date with the result that at some time or another, they are faced with a comparatively enormous expenditure to put their house in order, and unfortunately this expenditure comes at a time when they are usually feeling the pinch, due to someone starting in competition with them with the latest equipment in first class order. Manufacturing to-day, is to a large extent a battle of equipment, and unless one keeps ones production machinery in first class condition, the inevitable result is that the quality of the product drops and the cost of plant maintenance mounts up to an alarming figure.

I would recommend you to read a book on this subject entitled : *Machine Depreciation and Wasting Assets*, by Locke, as it sets forth very clearly this position.

As to pride in having the best equipment, there are still some people who are proud of the appearance of their shops and look upon it as part of their advertising scheme to be able to point out that everything is of the latest and best, and I believe that it is an argument which is well worth considering. I remember some years ago, selling machinery to a firm to the value of some £8,000 and the managing director remarked, as he passed over the order, that from an economic point of view he did not believe that the purchase could be justified but he could not afford to allow his customers (particularly foreigners) to come round the works and tell him of the wonderful machines which his competitors had for that particular class of work.

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In closing my remarks, may I issue a plea for the non-productive machines. It is a fact that in many factories some of the non-productive machines (which are in themselves essential to the smooth working of the factory) have very little consideration. One is frequently met, when soliciting orders for this class of machine, with : "We have no money available for non-productive machines so they will have to put up with what they can get." This in itself is often very uneconomical if the position is closely investigated.

Mr. J. D. SCAIFE : The word "economics" in the subject is worth thinking about, because it does imply that of late years economics have entered into the question of buying machine tools. I am not very old, but I can recollect the time when the works manager used to be his own efficiency department, and bought his own machine tools, and the order generally went to the man who supplied him with most beer at the nearest pub. That state of affairs has largely disappeared now, because in most of the larger works there is an official appointed to knock something like economics into the purchasing of machinery. Taking the subject by and large, however, there is not the amount of thought being put into the purchase of machine tools that I would like. There is still, I think, some relic of those old days of the beer business. It is not exactly so crude as that, but there is something ; perhaps the buyer likes the colour of the salesman's clothes, or his hair ; some personality of the salesman goes with the buying of tools. That, of course, is not economics. I was faced the other day with a concrete instance which is perhaps worth a little thought. I visited a man who was making electric motor shafts. His method I considered very antiquated, but, as he said, he always made a profit. We had an argument. His method was this : He started first of all with a cut off the bar ; he had a sawing machine in his equipment (or itinerary, because he had quite a long way to walk to get round) skimmed and then turned it ; then he keywayed it and then he ground it. He said, "I pay a man so much for doing that job ; can you beat it ?" I said I thought I could, but it would require some doing, because the price he paid was cheap and took a lot of beating. In the argument, I said, "We will suppose you wanted to double your output. You are going to have a pretty big job ! You would have to double the size of your building, double your power, and you would have to go raking round the universe for a set of antique equipment such as you have got now. In fact I do not know how long you are going to be allowed to use it, because in some districts you would not be allowed to." That is a problem for the economics side.

I have been a buyer for some years, and I have been a seller of production machinery, and I have never considered the question very closely because I considered the purchase of machinery was a

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matter of common sense applied to the particular job. For instance, a certain factory manufactures an output of so many articles per week, the cost at the present time being so much on a certain machine. The purchase of new machines with a guaranteed output would show a definite saving, making it worth while to buy a new machine. If the saving were sufficient, they would buy the machine—if the money were there. My difficulty has always been that I have never been able to get sufficient money to buy all the equipment that I wanted, and I have only been able to get sufficient to take off the high spots. Two factors enter into the question. One is depreciation. But the question of obsolescence is an entirely different thing, and this question, I think, was raised by Mr. Fenton when he separated special machines from standard machines. It is obvious, of course, that a special machine has to be treated differently from a standard machine because it has been designed and made for one particular purpose, and as soon as any special machine is designed and put on the market for improving the output of that particular job, the earlier one is obviously ready for the scrap heap.

To come back to the subject of economics, I think that at the present time the subject is too detailed and concrete to treat in the abstract way in which Mr. Perry-Keene dealt with it. The side of the subject he dealt with was one I should like to discuss if there were time. I think that problems can always be dealt with on a common sense basis, and as a salesman I cannot too strongly recommend that machines are bought strictly on the economic basis, the cost of output and maintenance taken into consideration, and, if necessary, points given for various features, like a system Mr. Youngash got out very recently for the application form for membership : so much for this, so much for the other, and adding them all up together. I knew one man who bought machinery like that ; he made a chart up of so many points for speeds in the gear box, positions of the spindle, and so on.

MR. FIELD : Is he still in business ?

MR. SCAIFE : He is not. (laughter).

MR. T. A. JACOBS : I have been very interested in Mr. Perry-Keene's remarks, and one thing which strikes me very forcibly is that we are told that we ought to buy new machinery for producing, but we are not told how we can measure what we have to do. We have a machine in the shop, and someone may come along and say, "We can do with a new machine," but, in my experience I have found that it has only been pure guesswork. May I give some examples ? If they ask for a new machine to replace an old one, they must have some reason, and it must be because they can produce more. If they can produce more, they must know whether the old machine is turning out the quantity it ought to turn out ;

they must have some method of measuring whether that machine is turning out its full capacity, and to compare it with the new machine. I had to deal with this subject in 1912, in the case of a horizontal miller which my firm had bought and had had for nearly twenty years. I worked certain things out, though I had only crude ideas at that time, and found, after a little study, that it was only a multiple tool; if it had a certain strain put upon it it would break. I carried on, and it was amazing what happened with this old machine. We had been turning work out in four hours actual production time, two in one hour twenty minutes. At this stage I was informed by the chairman of directors, who happened to come round when I was standing by this machine, that they had nearly finished making a new machine for doing that class of work, as they could not get the production they wanted. I said, "That is strange! Taking a rough guess at all your production for twelve months of this class of work, I dare say we can produce all you want on this machine." He was amazed. The machine being made was to cost about £1,000. They completed a test on this new machine, and found it could not do as well as was done on the old machine. The new machine was never put into commission.

In another case I was asked to get a machine to replace an existing one. I went into the matter of the production that was done on this machine, and, to cut a long story short, I started producing just five times as much work on that machine in the same time as was done formerly, at no extra cost whatever. The cost of the machine to replace this would have been £400. We sent them samples of the work, and the new machine could not produce the work any faster or any better than this machine which we had, and which only cost about £250. The point is this, before you say you want a new machine, first see that the old one is turning out what it can do. Before that you must have some method of measuring. I have been in several factories and have studied this problem very carefully, and I have not come across one factory where they had any standard of measuring this. I should be pleased to know if any of the members know of a method. In one factory they had a big efficiency department, and everyone in that department was studying from a different angle of measuring. The difference in the result was surprising.

I should like to know if Mr. Perry-Keene can suggest any method by which we can decide whether a new machine is necessary, and whether it is going to be economical over the old one.

MR. PERRY-KEENE: That question is an extremely pertinent one, and I am very glad to hear it. There is not the slightest necessity to measure or be at fault, but we do not want to start measuring at the machine end, that is where we are wrong. What we have got to do as production engineers should be as clear as

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daylight. Do we use our brains sufficiently? This is what we have to do. The whole of the facts are measured for us, cut and dried. It remains for us to translate them. Here is the method: What do we live out of? Obviously out of the market. What is the market? The market is the price for an exchangeable entity or series of services. Let me assume for a moment that all of you are buying from me—a manufacturer—a motor-car, and you all put up your hands and say the same figures: that £100 is the price of the motor-car you wish to buy. You have told me everything I want to know. You have told me the cost at which I have got to conduct every single operation in that product.

I start this way. I reserve out of the £100 the necessary profit to pay for the use of capital and for future development of my undertaking. I then break down the commodity into book form in terms of operations to produce each article: for a crankshaft say 40 to 48 operations, for a connecting rod, so many operations, and so forth. That will disclose to me again, something I have got to tell my workmen. I will say in effect to each individual workman, "The public or market, out of which you live, says you have got to do this operation for .7 minute, and that for two minutes," and so on. What do we do at present? We actually establish cost systems that tell us what a thing has cost after it has happened, when all the time we could know exactly what it has got to cost before we start it. That indirectly measures for us automatically every item of plant we have to employ to manufacture that product at a correct price.

In the future, something of this sort will happen. I would have my factory laid out on these lines. I would have my executive side, commonly called the office, so competent technically and from the point of view of market dealings, that they would clearly translate for the use of the works the monetary or market problems in terms of both finance and mechanisation. I would indicate from the office that this or that item of plant could never do the job. Before I ever started I would employ a production engineer to produce a suitable machine that would do the job. Instead of that we buy a jumble of machinery, we go into the drawing office and design something, take it down into the works and it comes out as a finished entity. The cost accountant gets it and he says "It cost £10." We come to the market problem and then find we are offering this £10 article whereas the buyers have not got more than £5. That is the way I would tackle this problem. We acquire machinery, and do this and that, then we encounter hidden things, as for instance agreements between labour and management, and often we find we cannot use plant to advantage. How to buy the most suitable machinery for our purpose is the continuing problem.

If I had my way I would startle people by putting in huge letters

on the gates of my factory something that would make the world remember how it gets its living. "NO WAGES PAID : 2s. 6d. ENTRANCE FEE TO COME IN." I would demand that sum from every labourer and executive to let each man have the privilege of entering the place and of earning his living. I would continue my legend, by saying, "ANY MAN WHO FAILS TO EARN £5 PER WEEK WILL BE FORTHWITH DISMISSED," and then I would finish by saying "I WILL SHOW YOU HOW TO DO IT," and when he had learned how to earn £5, I should say, "Why don't you reach £6?" We want machines, but we do not want agreements between ourselves to limit their capabilities. We find ourselves getting poorer and poorer because we are saying in effect "Proceed at the speed of the slowest," instead of saying "Make everything you can, the market wants it."

We are now on the edge of a national problem. Intense competition tends towards making, say, four pairs of boots where two are enough, whilst there is an obvious shortage of goods in other directions. We are therefore, in this instance, using up human energy to no effect, yet we are short of something that is calling for a proper measure of planned use of that human energy. Every one of us in this room, in the world, is short of goods. We can produce them—there is no question of that—we can produce them at prices that we have not even visualised to-day, but we have not learned to finance such schemes.

That brings us to the question of measuring the machine, and the answer clearly is this: that we have at hand, every one of us here to-night, the solution of the problem. We know in the first place, without any question, the price of time (never mind money) which the public will pay for every operation. It is up to the production engineer, aided by suitable executive, to carry to the finish the solution of that problem.

A MEMBER: I think it is always a tonic to hear Mr. Perry-Keene, although I am sometimes at a loss to know whether to take him seriously. He always makes such specious statements about fixing prices. I must confess that in my humble experience it leaves me somewhat baffled. There are one or two questions I should like to ask Mr. Perry-Keene. First of all, there are certain elements of cost which, presumably, are quite outside his or our control, for instance the pig iron he uses; he has got to pay for it, something in the region of £3 per ton. With his raw material, I cannot see at any rate that he is going to alter the price of that, unless he is going to manufacture everything; then, of course, he may be able to do it.

In looking at the motor-car, which is the example he has taken, the cost is made up of such items as leather to make the upholstery, wire to make the springs, and other raw materials which have got to

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be purchased by him, and over which, presumably, there is very little control. That, I presume, must represent quite a large element of his cost, and whatever he may say to the production engineer from the point of view of the machinery required to fabricate it, he has got to go to the suppliers for his raw materials. I think we have got to take production machinery as it stands at the moment. We have got to agree that there is a limit to what can be done, and that can be fixed by the degree of skill or knowledge of the technicians who are designing these machines. We cannot say, "This costs £7; it is now going to be introduced at 5s." Production machinery cannot as yet have reached that degree of skill or technique of calculation. I should like to hear his views on those points.

MR. PERRY-KEENE: That is a useful question. If, in that world which I forecast, our buyers were competent, they would convey exactly what I tried to convey to you just now, to the suppliers of iron, textiles, etc.: "Look here, the public are paying you this much time. That time is money, and if you don't conform to it you perish, and we also perish commercially."

It is a fact that the company I serve has, in 14½ years reduced prices in this measure. Where we had to charge £100 for an article (we could not make a profit at that; we made a loss) we will sell you that same article to-morrow at £23. That is practice—not theory. This has been possible because we have, in the main, been able to convey to suppliers that we do not buy from them—we are agents—it is the public that dictates in real fact the price at which the job has to be done, or we all perish.

I would like to illustrate those facts by certain figures that are taken from our books, and have been maintained for years. There is in England a certain manufacturer of crankshafts. We were prepared to place orders for £30,000 worth of shafts, and asked for tenders. These came in, and the price was £15 12s. 8d. each. After a final struggle with figures that was reduced to £13 4s. 6d. Our translation of the public demand was a very different figure. It was 57/- . I will tell you the actual cost of production, including writing off the plant in four years. It is 42s. That is something that we were told could not be done. Yet it is done—easily. Another job, for which the production time to-day in Germany and France is over 200 minutes, is done by machinery which we have designed and produced in response to this dictation, in less than ten minutes.

Now we arrive at a truth. We engineers are without doubt the Cinderella of all primary trades. We find added to semi-raw materials altogether too much time, which is money, and so produce commodities at a ridiculous cost, and then complain that there is no trade! The figure you mentioned just now—"the uncontrollable figure" for material—is 47 per cent. of net sales. One

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might say that figure is uncontrollable, yet we have in a great measure, by approaching people (and here is the test of it—in reducing the price from £100 to £23) persuaded suppliers that the facts are as we state, and in that falling price curve the cost of material has never risen through it. In doing what we have done, we have as you know, expanded from 3,000 employees within our four walls to over 20,000. Looking at it from a sociological point of view, which is always very closely allied to economics, we have paid out nearly £130,000,000 in fifteen years in wages and salaries. Through that little bit of energy and creative thought we have expended, we now utilise in England the services of about 127,000 souls, working forty-seven hours a week, fifty weeks in the year. Further, it keeps in all amenities of life the families of these people, from which a simple calculation leads us to the fact that we are feeding every day over 400,000 souls, which is a national contribution politicians should appreciate.

MR. T. R. MELHUIJSH : One point about which I was anxiously waiting to hear in the matter of the economics of purchasing production machinery was the design of that machinery to allow of good maintenance. When I touch on the point of maintenance, I mean in the case of production of a particular component per 100 or per single unit. A great number of machines are purchased to-day with a view to the floor-to-floor saving in time. A great deal of that saving economically is lost by the design of the particular tool which it is necessary to use with that particular design of machine to produce that particular component. There is a great lack of design for adjustability. As everyone knows, the adjustability of a machine allows of a bigger range, on an economic basis, of the use of an individual tool. I have in mind now the design of a machine for producing a component where it is necessary to have a reamer $1\frac{1}{2}$ in. diameter, 14 in. long, and, due to the lack of adjustability of that particular tool, only $\frac{1}{2}$ in. of that very valuable and expensive article can be used, that is, from the drilling and reaming standpoint when used simultaneously.

I also have in view milling operations : machines and jigs designed to give a floor-to-floor saving in time by the ganging of milling cutters. That ganging of milling cutters must be maintained for special sizes within the limits of certain thousandths. The more use that a certain individual milling cutter has, means that one of these cutters gets worn out considerably quicker than the remaining cutters included in the gang. Now all those conversant with milling know that to replace that particular worn cutter to work in conjunction with gang a new cutter would have to be ground down to the required size of the other existing ones, or scrapping the whole number. I know that in a great number of cases it is put forward that these can be used up in other directions. Possibly

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they can, but I know from experience that a great number of these become surplus to the requirements and can only be put away on a shelf and ultimately sold at whatever they can fetch.

I turn to another item, and that is grinding. We have grinding machines to-day which necessitate a very large diameter wheel. There again we have little adjustability or changes of speed to accommodate the wear in diameter. We have got expensive wheels to purchase which in some cases can only have as much as $2\frac{1}{2}$ in., in the case of a 24 in. or 26 in. wheel, worn from that wheel, and the remainder becomes scrap because, owing to the particular component for which that was designed, it cannot be accommodated in another direction.

MR. PERRY-KEENE : I am afraid we can guess at the name of the designer of some of those machines. He must be called Mr. Mug ! I think that is an illustration of the economics of the machine, which is a thing we have not had time to touch on. If that designer, and the executive who was capable of translating the market problem into the mechanical problem were thoroughly *au fait* with their subject and collaborated entirely, I do not think that sort of short coming would ever arise.

There is a tendency in machine tool design, just like there is in manufacture, towards drawing out a thing, putting it together and putting it on to the market without further consideration. Sufficient creative thought has not been put into it from both angles, the prime cost and the ultimate cost, which is the prime cost plus the oncost. That has never been considered, otherwise those circumstances just described would not possibly arise. In my scheme of measurement, anything of that description would be avoided, because the very fact of purchasing any machine ensures that its capabilities and performance has been thoroughly investigated, its life in terms of hours of work taken into consideration, the possibility of revitalising or rebuilding it from time to time also looked into, and the whole problem treated properly and honestly from a capital point of view ; " Will that £100 that we spend on that particular entity see us through at the correct market price ? What is the relation between the entity it manufactures, and that market entity ? Will it see us through to the end of its term of active life ? "

Those are the questions we have got to put to ourselves before we ever touch on the economics of buying one unit. If we sin by failure in that direction, obviously some of the profits will disappear, but if we look at profit making as an extension from the other angle I mentioned just now—each individual operation—we find ourselves in this position. Engineers have invented for us machines that can analyse at a terrific speed, and show exactly what the capital value of that plant has achieved through the human entity which handles

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it. Therefore we can relate automatically the human unit to the machine, as a friend not as an enemy. If we will think along these lines of pre-determination, that is, not waiting to know what it does cost, but pre-determining what that cost has got to be, we should never make mistakes in the selection and buying of machinery along the lines Mr. Melhuish illustrated.

MR. FORD : As an equipment engineer, I find that the buying of machines does not work out quite so simply as I would like it. As a matter of fact most of my time is taken up in two ways: half the time I am trying to persuade the management we want the machines; the other half I am trying to persuade machine tool salesmen that we do not want that particular type of machine they have to offer. Consequently I have very little time available for actually thinking out the economics of the question. Furthermore, if we do set down on paper the machine we think can give improved production and calculate that if we buy this certain machine at such-and-such a price we can save 1.78 each, and the machine will pay for itself in one year, nine months, thirty days, the management may decide they will erect a new service department or a new canteen, and "they are sorry but they cannot spare any money this year, you will have to wait."

I cannot help but echo very strongly that which Mr. Fenton said in conclusion on wasting assets. You have plant in the factory which, at a given year, stands on the books at a certain figure. As each year goes by those machines are depreciated at different figures, varying from $12\frac{1}{2}$ per cent. to five per cent., and each year your plant, if you do not add to it, becomes of less value. I strongly believe that the difference in value from one year to another is just as much a charge on production as heating and lighting, or rates and taxes. Whilst men of Mr. Perry-Keene's high standing work all these figures out, they are very reluctant to allow money to come out of the bank at the right time to do these things. It seems to me that if we spend money when we are busy it is too late; we have to spend money when we are not quite so busy in order that the machine will be delivered in time for when we shall be busy.

Another thing that enters into the question is, when considering buying new machine tools to effect a saving, the result of your paper work is often very disappointing. If you work it out, it will often take about ninety-nine years to pay for the machine ! When you have that condition you think "I can buy this machine and effect a saving if I can dispose of the machine I am using economically," and therefore the design or type of machine you buy is largely influenced by what you can do with the machine you are releasing.

Another aspect I have very little doubt about is that many firms analyse the cost at which they are producing an article and find

that it could be produced much more cheaply on much less expensive plant but, owing to the fluctuation in the sales demand, they have to have the plant which can be delivered immediately.

One thing that strikes me very forcibly is that I think we have more cases of machines being put up to us for consideration which are too fast, than too slow. It seems to me to be of little use buying a machine which will produce the whole of our output in two days when there is no hope of that article ever reaching a figure which would fully occupy that machine. Although the available time can be used on something else, when you once start doing that you start a whole series of costs in motion which will be very difficult to check, change-over times, idle times, and so forth.

The type of machine required nowadays is one on which the purchaser can work out the time factor for the components he wishes to produce, allowing a reasonable estimate for increased amounts, that time factor being the governing idea in the purchase of the machine. Again, if we could employ a machine which was exactly the right type of machine for the article we were producing, we should make a very great saving, but evolution goes on, we make one thing one day, another the next, and so on, and for this reason it is most necessary that we keep our plant like a Meccano set.

MR. PERRY-KEENE : You have raised that hare—it has four strong legs, let us chase it! You have really run outside the title of this discussion, and you have run right into the economics of management. The less I say about that the better. Reverting to the true subject, there is a direct economy in certain well defined directions in purchasing and using what we might dub "ideal machinery," machinery capable by its great speed of using that infinitesimal amount of labour, so small that it is actually an economic fact that it is correct to purchase it and let it run twenty hours per week instead of forty-eight.

Reverting again to the economics of management, if our works managers (I am sure there are no production engineers among them) are such mutts as to allow this to happen that you are not able to purchase machinery when you want to: it means, at any rate in real fact, that they have at some time or other been paying profits out of capital. If you depreciate your plant upon the correct lines—and these are the correct lines—though not in use yet except, possibly, in our company, three factors enter into it. The first one happens to all of us—age. Age will some day remove it. The next item is the actual number of working hours that have been put through the machine, tempered by the class of operative who has got hold of it, whether rough or smooth. The third item is the re-creative work you have put back into the machine. These three factors give the true intrinsic value of the machine. One of the most futile things we do is to say "Its depreciation is seven

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per cent. $10\frac{1}{2}$ per cent., or eight per cent. Here is a truism—amongst all the hundreds of machines you have in your plant, no machine has the same depreciation.

The position we frequently find to-day is, we pay profits out of capital, we cannot buy machinery when we want it, and we have the extremely silly habit of costing by units. We cost a unit and if a loss occurs are left in the lamentable plight that we cannot say which of the operations has let us down. The method we pursue is, to determine the cost of every operation and, by reason of using that modern analysing machinery we can tell, whilst a man is doing the operation, whether it is good or bad—that it is profitable or the reverse.

A MEMBER : Everyone here has been particularly concerned with increase of production. This is very desirable, of course, provided there is the demand for that increased production.

Mr. Scaife mentioned an antiquated place where the individual concerned was making his work an economic proposition. The fact remains that he was carrying on. If all these things happened that we have been visualising to-night, obviously he would be on the unemployed list, although we should change the status of the unemployed by saying "leisured." He would cease to be a purchaser and production power, and would rapidly fall into the hands of a cartel or monopoly, and, as their huge producing power would be so great, they would be able to cut out everything and everybody. The amount of productive labour they would require would immediately fall by a tremendous amount, which would inevitably mean that purchasing power was reduced, and we should be worse than we are to-day, with two-and-a-half million unemployed. That aspect does not seem to have been touched on at all.

MR. PERRY-KEENE : The answer is comparatively simple. A census of production in Great Britain has disclosed the following amazing facts. The trend is very clearly shown. There are in the kingdom 134,000 operating firms, but $3\frac{1}{2}$ per cent. of those firms employ 50 per cent. of the employed persons in the kingdom. That is a reminder that nothing is static. We are always subject to attack. Even if we are successful, and keep alive and pay dividends and make profits, there is always an enemy round the corner.

We production engineers are the only ones who can save that position. Financiers can help but cannot save because of the simple fact that all the money and goods in the world would only keep that world for something less than fourteen days. The only way we can maintain ourselves is by creating, creating and yet again creating more and more entities by means of the machines that production engineers acquire and utilise.

In view of that it is perfectly obvious that if any firm stagnates for only a short time, exactly what you are describing is bound to

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happen, but if on the other hand, we are alive and alert, and apply constructive and creative thought, we are bound to succeed. The world is very young, only three hundred million years or so, and it has not given us with our slow wits time to develop what lies in front of us—colossal and enormous markets. Presently when we realise that it is only necessary to work four hours a day, that very fact will release to us time—our friend in this case. We shall then require other entities and exchangeable goods to use up in that time, either playing or its equivalent, or educating ourselves.

The truth at the back of the economics of production is this. We have not realised, and we are at the moment incapable of realising, how great the world's markets are that lie in front of us. In a short time, twenty years, this extraordinary change has taken place in England. If we set out in diagrammatic form the incomes per head of the population of 48,000,000 we shall find this amazing figure. After ninety years of more or less profound peace, at the end of 1913 every individual in the kingdom had an average weekly income of 10s. per head, man, woman, and child.

Then we find war breaking out, and about 1918 there is an extraordinary development of that curve. It jumps to £1 6s. There is, however, a canker. That money was false money. It was paid out of capital acquired : and then the crash came !

We thick-headed Britons as usual, faced it, thought it out, and subconsciously and without knowing much about it we have created another extraordinary position. To-day a week's income stands at £1 8s. 9d., brought about very largely by the production engineer. The manufacture of entities, and the circulation of money caused thereby, has established the fact that the average income is that figure. From that it is easy to visualise what has happened in our lifetime : if we do apply creative effort and go further and further along this line, there will be, in answer, an even greater and greater income, accompanied by a measure of unemployment which is a gift ; it gives us an opportunity of thinking out our problems more quietly ; to amuse ourselves ; and, above all, to educate ourselves.

Talking to professors at many universities has brought this fact home to me. It is a modern problem. For forty-five years I have kept accurate figures relating to thought and action. I put those into writing and found that 2.41 per cent. of persons think and act A month or so ago I asked a well-known statistician in London. He said, "I have studied that, and the percentage is 2.40 per cent. We only varied one degree in the second place of decimals, so there is obviously some truth in it ! If we can get our thinking factor on to a higher level, and not leave it at 2.41 per cent. out of the whole of the population, we should help ourselves along the line we are pursuing. When some of these contrasts are given, more than one

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person has got up and said "Arabian Nights again," but I assure you that everything I have mentioned to you to-night is from actual practice. It is capable of being done, and I am confident that, of all the people on the earth who can help that sort of thing forward, it is the production engineer.

MR. S. M. CHAKRAVARTY : I greatly appreciate the way in which Mr. Perry-Keene has treated the subject to-night. As a production engineer I feel proud to think that my occupation has its humane and ethical aspects as shown by Mr. Perry-Keene, but I wonder if Mr. Perry-Keene, in taking a very wide view, has introduced certain points that involve international politics and economics. For example the problem of adjusting the exchange value of commodities produced throughout the world. Taking the case of raw materials as compared with manufactured goods, there is such inequality in exchange value that I do not see any prospect of that problem being solved within measurable time.

Coming to a point of Mr. Fenton's, where he mentioned the difference in buyers' and sellers' psychology, I suggest that the solution lies in a proper co-ordination of the economics of selling with that of purchasing. Mr. Fenton also mentioned that people will change their motor-cars every year, but not machine tools. The reason, I think, lies in the difference in the use of the two articles. There is no royal road for using machine tools as there is for motor-cars. Part exchange method of selling cars is also a strong incentive to having a new model every year. There is no such facility in the sale of machinery. The use and advantages of machinery are comparatively obscure, hence greater effort is necessary to convince the customer. This can be done by advertisement, demonstration, and service. I think the motor-car industry has much better facilities in the above directions. Excellent service departments for automobiles have long been established in India, but there is no such facility for machine tools. As late as 1932, a friend, who came from a very advanced factory in India, told me that they had tungsten carbide tools, but they were of no use as they did not know any means of grinding them. I took the friend to the firm where I was at that time, and showed how tungsten carbide tools were ground and used with great advantage on high speed capstan and turret lathes. In my opinion, the machine tool industry may gain immensely by organising better facilities of demonstration and service, especially in distant markets.

MR. R. H. YOUNGASH : I had hoped to have been spared from speaking this evening, on the principle that, if doctors disagree, who shall decide? But I have not seen much evidence of disagreement. The primary reason is, Mr. Perry-Keene has covered the particular aspect of this subject which appeals to us most to-

night. He has, however, run briefly over many other aspects of an extraordinarily interesting subject.

The title of our discussion to-night is "The Economics of Purchasing Production Machinery," and I hope that you are all entirely satisfied with your personal understanding of the word "economics." Personally, I feel it should be placed in the category of those words that all the speakers at these meetings carefully avoid when I am here, mass production and fabrication. I think economics should be added to this list because, if there is one word in this language of ours which is used to cover a multitude of sins it is surely economics.

How do we purchase machinery? One can visualise that a man, or body of men, may form a company for the purpose of producing an article or assembly of units which, for all intents and purposes, becomes an individual article. They say that they are prepared to put a certain sum of money for the purpose of pursuing an object—making money. The object behind it is to obtain a profit out of the making of it, and if the public are not prepared to pay a price on which they can make a profit, then they very quickly go out of business. Whilst there may be some grounds for saying that you can set out to make an article at a certain price, it would be a very rash man who would say that you can only sell it at one price, so many factors enter into it.

We come then to the real point in purchasing machinery. This depends entirely on your finances. It does not need any words from me to tell you that Mr. Perry-Keene is not personally occupied with direct supervision of machinery. On the other hand, I am equally sure that if I were to go to Mr. Perry-Keene to-morrow morning and say, "I require a sum of money for the purchase of certain machines," I could convince him that the bulk of the money would be very well spent, as also could all those who occupy similar positions to my own in the works with which we are connected, but the final test is one's ability to pay for it.

Much has been said to-night about depreciation of machinery, and I wonder if those who recommend that machinery should be depreciated or extinguished in four years have ever tried to persuade the income tax people of that, because I do not think they will be very successful. If they should be, then I certainly know one or two people who would like to know how they did it.

We have to put some sort of life on machinery. I remember in 1904, in the section I was in charge of, we had a certain machine which bore a plate stating that it was made by Whitworth in 1864. It was thus forty years old. That machine at the time was capable of doing quite good work in keeping with many of the machine tools of the day, but what is the position now? The machine, not of 1864, but of 1924 is now so hopelessly behind in productive capacity

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that it is positively of no use. When you want a new machine, you must have good and sound reasons for wanting that machine. There are just one or two that are sufficient. The first is that you cannot get the required output from existing plant ; the second is that the existing plant is giving you too much trouble.

Mr. Fenton mentioned pride in possession. It does not apply in every works. Pure necessity becomes the real reason. We do buy our plant ; we do spend the money ; but we do not spend it in the particular direction that an individual would like it spent ; I would like capstan lathes, while someone else would like a press. That is a point in the problem which is an extraordinarily difficult one.

There can be no question about the fact that it does pay to buy new and good plant. Perhaps it does not pay in exactly the same way as the salesman would make us believe it does, because another factor, I am afraid, comes in here. If you buy one machine to replace two old ones, you have still the same or greater overhead on that one as you had on the two previously ; you save very little in floor space, nothing in supervision, though you may save a little in labour. You come to a condition where you can easily see two works running side by side in the same town ; one is up-to-date, the other equally out-of-date, although they both continue to make a profit.

MR. E. W. FIELD (Section President, who presided) moved that a sincere vote of thanks be accorded to Mr. Perry-Keene, Mr. Taylor, and Mr. Fenton for their contributions to the discussion, and this was adopted.

PAINTS FOR ENGINEERING PRODUCTS.

Paper presented to the Institution, Eastern Counties Section, by H. Peters.

I MUST thank you for the honour of being allowed to address you to-night. It gives me great pleasure to be here to speak to you for a short space about a subject which is not only my work, but also my hobby. I hope that when I have finished, you will not only have been interested in what I have said, but I trust I may have aroused your enthusiasm for the subject generally so that you will take much more interest in your paint shops in the future. I am sure that all sales departments represented here to-night will agree with me that an article painted well is much easier to sell than one painted badly, and also much more likely to bring in repeat orders.

My first thought in introducing this paper was : " Why should they paint them at all ? " and I expect that if I asked each one of you this question the answers would vary considerably. My answer would depend on what you replied, but I think we could sum up your answers under three main headings. I submit to you the following three reasons why you should paint your products : Firstly—for protection ; secondly—to brand your product ; thirdly—to give a clean and durable finish to your product.

Protection.

As a general rule with this type of work we have only two materials to protect against the elements. These two are : metal and wood.

On mentioning metal, the first thing that enters your head, I have no doubt, is that word " corrosion." This occurs in more ways than one : (a) By oxidisation of the metal owing to its contact with the oxygen in the air and, of course, being accelerated by the presence of moisture, carbon di-oxide, and other acid fumes. (b) By galvanic action on the surface of the metal ; differences of potential are set up on the surface. The result is the solution of the metal at the anode, its deposition at the cathode. (c) By the action of sulphur direct or through a sulphur carrying bacteria, all sulphides being easily decomposed to the oxides. (d) Speed of corrosion can be due to the catalytic action of colloidal ferrous hydroxide, but, if the formation of this can be prevented, the rate

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of corrosion is considerably lessened. Rust or corrosion, if once present cannot be stopped by the application of the suitable priming coat.

First of all the metal must be thoroughly cleaned, free from all grease, rust, and dirt, and for this we suggest the use of one of the phosphoric acid preparations such as Dockers' Primo-Surfacer, which is applied with a brush, washed off as hot as possible and then the priming coat applied as soon as practicable afterwards.

This coat must fulfil the following requirements : (1) To prevent carbon or electrolytic corrosion setting up. (2) To stop the action of sulphur and its compounds, or else ferric sulphide is formed which decomposes to the ferric oxide. (3) It must contain a germicide strong enough to kill all the sulphur carrying bacteria. (4) It must contain a crystalloid to retard the catalytic action of the colloidal ferric oxide.

Unfortunately to get a paint to fulfil the foregoing requirements and also to be durable is not at present a proposition, and therefore it is necessary to protect the priming coat from the atmosphere. As we have already buffered the metal surface with electro neutral material, for the second coat we can use a carbon paint, which is the least affected of all materials by the light, sun, moisture, and acids, and therefore it will be seen that between the coats we have fulfilled all the requirements demanded. In the writer's opinion it is quite impossible to prevent corrosion for any length of time by the use of one coat of paint, besides not being able to get all the required properties combined into one coat the thickness of the film is not sufficient to cover all the inequalities of the metal.

Wood.

The main troubles here, of course, are dampness and sap, which cause the warping or cracking and deterioration of wood, sap being the main cause of deterioration. It is most essential, before painting, to see that the wood is dry, because first of all no paint will adhere to wet wood, nor when it contracts with drying or warping can we prevent the paint cracking. Sap consists of acids, salts, and pulp, which attack the paint, and the best way of curing this is to allow the wood to mature in air and rain and then dry in a kiln.

After the priming coat the next essential is for the wood to be filled up to obtain an even surface with the finishing coat. This is done by employing a wood filler, the application being one of three ways : (1) If the cracks are very fine one or two coats of filler sprayed should suffice. (2) If the cracks are deep it is better to brush the filler on, as by this method the filler is poured deeper into the cracks. (3) If the cracks are too large for this way, we have to resort to the knife filler or stopper, which is put on with the ordinary palette knife. Large cracks between joints, etc., in wood

which require too many applications of stopper or filler are best filled up by means of plastic wood. Of course, all these methods have to be flattened when they are dry before applying the subsequent coat.

Marking or Branding.

I think you will agree now that we have got our metal or wood cleaned and ready for the final painting process, and so for a few minutes I want to turn to our second point, that is : the mark of product. This is, in my opinion, purely a customer's fancy, as we all know their articles by their colours. To come to Ipswich for a moment, anybody seeing a blue plough would know that it was manufactured by Ransome's, having been painted in what is commonly known to us as "Ransome's Plough Blue," and again we might take as an illustration a London Midland & Scottish Railway Lake colour. We have only to look at a railway carriage and, without reading the name, we all know to what railway it belongs. This is only because each of the four main railways has its own distinctive colour. So I think we might say another reason why you paint your machines is as a form of advertising, so that a person sees it and knows by the colour who the manufacturers are.

Finish.

Now we come to our third point—to give a clean and durable finish to your product. As I mentioned earlier in this paper, an article well painted will not only look nice and clean and fresh when it is despatched, but it will also keep its freshness for a long time, and this, I am sure you will agree, is a great point from a sales view.

After this general opening let us now think of the paints themselves. We can put these into three classes : (1) Oil paints and varnishes. (2) Nitro-cellulose. (3) Synthetics.

Oil Paints and Varnishes.

The first I propose to pass over very briefly as we all know about these, and the snags which are connected with them, for instance, the long drying time required for the finishing coats, which not only hampers the despatch department, but also has more chance of picking up dust and dirt to spoil the finish. If these two difficulties could be overcome, nothing to my mind still looks quite as nice, nor will wear as long as a piece of machinery finished in the old-fashioned way with paint and varnishes. It needs at least two coats of hard drying body, and one coat of best finishing body, but I am sure very few of you here could allow the time for drying in these days of rush that is necessary for this finish—that is, if this type of finish is going to be a success.

Nitro-cellulose.

Next we come to the nitro-cellulose which has many advantages, and yet, in your production shop will have as many disadvantages. The main advantages are, of course, speed of drying, giving a very hard film which can be easily cleaned, and is not easily marked. Against these advantages we have the disadvantage that nitro-cellulose has to be spray-applied, and to get a good job cannot be brushed, and, as you know, the flash point of nitro cellulose being under 73°F., we come under the Home Office regulations for this type of paint. This means setting up special booths, etc., for the application, and this, apart from its own inconvenience, often with the bigger type of machinery means further trouble by bringing the machinery to these booths instead of taking the spraying machine or the brush hand to the machinery.

Before leaving nitro-cellulose I might mention that there are two processes for this material. One is known as "the combined process" which is built up with an oil base primer and filler, then a buffer coat which consists of a special medium which adheres to the filler, and yet does not allow the thinners of the cellulose to penetrate. After the buffer coat the article is finished off with ordinary cellulose colour coat. The other method is a "direct process," and this consists of cellulose throughout; cellulose primer, cellulose fillers, and cellulose colour coat. The direct process is, of course, much quicker, and gives equally good results. Why the combined process came into being was that in the early cases a direct process primer could not be obtained that would adhere sufficiently to the surface. The paint chemist got to work on this, and the difficulty has now been overcome, and the nitro-cellulose primer gives perfect adhesion. Of course, after this, the direct process method was easy to put into practice.

Synthetics.

Lastly we come to synthetics, which for all of us here is, I think, the ideal of the three. It has the advantages of both oil paints and nitro-cellulose without any of their drawbacks. First of all it can be applied equally well by brush or spray, and its drying times are much quicker than oil paints and varnishes but, of course, not quite so quick as nitro-cellulose. In an ordinarily heated shop, i.e., 60 to 65°F., undercoating will dry hard in four hours. The finishing will dry hard enough to pack in eight to ten hours. Another advantage is that using a synthetic enamel you can get almost as high a gloss as an oil varnish without the use of a varnish. Synthetics, of course, can also be obtained in eggshell or matt finishes. Synthetics do not come under the Home Office regulations, as their flash point is over 73°F., and I know that this is another big point in their favour.

Thus I hope you will agree with me after these few observations that a synthetic is the best of the three for production work, and I hope that those of you who are not already using it in your paint shops will give synthetics a trial in the near future.

Application.

We have been talking just lately about brushing and spraying, and therefore, for a few minutes I think we ought to turn our attention to application, and here I would like to point out that I do not pretend to be an expert on this matter.

There are four ways of applying a paint to a given surface : (1) Brushing. (2) Spraying. (3) Dipping. (4) A way not very commonly used—flowing on.

Brushing.

Very little need be said about this, except that in my opinion if you are using a high gloss enamel or varnish the only way to get a satisfactory finish with this type of material is to apply it by means of the brush. It is too thick to be applied by dipping, and if the spray is used a certain amount of "orange peel" effect will be left, however expert the sprayer may be.

Spraying.

This is a method of application that has come to the fore to a large extent in the last few years, and to my mind, if it is used in conjunction with the brush, using the brush for places where if sprayed a lot of masking would have to be done, it can save a tremendous lot of time. There are two types of spraying machines, generally known as the high pressure, such as B.E.N., Aerograph, A.I.D., etc., and the low pressure machines, such as Kurt Erlach.

The principle on which the high pressure machine works, of course, is high pressure but no volume of air. The usual spraying pressure with this type of machine is between 50 to 60 lbs. per square inch. With the low pressure, or Kurt Erlach, the principle is a large volume of air, and no pressure. The actual air pressure being used on this machine is about four to five lbs. per square inch. Of course, one advantage of the Kurt Erlach over the high pressure machine is, that it does not give the amount of dust or what we call spray lash, and thus, if machinery is to be sprayed where there are no extracting plants, this is a point in the favour of low pressure, although the actual finish, particularly if you are using eggshell or high gloss, is not so good, more "orange peel" being obtained, and the work is not done so quickly as with a high pressure plant.

Our third method of application is by dipping. The advantage of this method is that if you have hundreds of standard articles to paint they can all be done by means of an endless chain and hot air

channel which, of course, obviates man-handling. The greatest care has to be taken to keep the paint at the correct consistency, else, when draining the painted article, you will find lots of paint at the lower edges. This method of application is used in the window trade where they have thousands of standardised casement steel windows and also it is used extensively in the japanning trade for small articles which are dipped before being stoved.

Lastly, there is the method of flowing-on. This method is not in use extensively, and is more often used where they want a cheaper way of dipping for a cheap article, and do not want to waste time or labour upon the painting. The term "flow-on" of course, explains the application where the paint is just poured on to the surface and left to drain.

The latest development in synthetics is the stoving synthetic, and where the article to be painted can be stoved, this is the ideal finish of all. The stoving, of course, is only applicable where you have all metal to contend with, as if any parts are constructed of wood the heat will make the wood warp. The drying times are short, and the surface is the hardest yet known in the paint trade. I have a series of "Thermolux" tubes in front of me, "Thermolux" being a stoving synthetic, and I would like you to try and mark these afterwards. I am sure that the results obtained will astonish you. The stoving synthetics led on to what most of the manufacturers of motor-cars are now using, the wet-on-wet primer-filler process, and then the cellulose finishing coat or "Thermolux" coat, the cellulose coat naturally obviating further stoving.

This method is as follows : Primer is applied and allowed to flash in the air for one quarter of an hour. The necessary coats—up to four—of filler are applied, allowing one quarter of an hour between each to flash off, and then the whole is stoved for one hour at 240°F. After this it is flattened in the ordinary course, and if the machine is to be finished in matt cellulose two or three coats of nitro-cellulose are applied, levelled, and polished.

This means that a motor-car can easily be painted and finished in one day. If the machinery is to be finished in "Thermolux" throughout the priming and filling procedure is the same, then a coat of "Thermolux" is applied and stoved at five or six degrees less for one hour at 230°F. If necessary another coat still five degrees less to avoid softening the undercoat is applied, and then it is polished and ready for the road.

Thus I am sure you will see what strides the paint chemist has made in the painting of a motor-car from the old days when it took anything from a month to six weeks—some coats wanting as many as three days to dry—to the present day when the whole car can be painted from the bare metal to the finish in one day, and I assure you that if your machinery is applicable for stoving there is no

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reason why this method should not be just as suitable and expeditious for you. The stoving, of course, is usually done with what is known as a conveyor oven, the heat of this being controlled by electrical thermostats so that you will get a perfectly even heat from the time the machine goes in till it comes out at the other end—a great asset where paint surface has to be done.

Discussion.

MR. C. H. WOODS (Section President) : There are three points I would like to raise : Is there not on the market a high flash cellulose which is suitable for working outside the Home Office regulations ? The eight to ten hours you give for drying synthetic cellulose is a long time for some of us, and we cannot always allow that time. With an oven conveyor it is possible to cut that time down two to three hours ? Is it not a practical thing to use cellulose for dipping ?

MR. PETERS : Dealing with your first question, there are high flash celluloses on the market and we manufacture them, but we do not like manufacturing them. We have found the results have not been so good with a high flash as a low flash, and where possible we like to supply the latter. Regarding the second question, I gave the time of eight to ten hours for air drying the synthetic, so as to be dry enough for handling and packing, but an oven conveyor will quicken that up considerably, and the average time is about one hour at 240°F. according to the colour. The trouble with dipping cellulose is the very quick drying properties, and there is a danger of uneven finish and blobs.

MR. RACKHAM : I am wondering if Mr. Peters would tell us a little more about the effect of lithopone in paint. Mr. Peters referred to paints for metal and woodwork. What about paints for plaster work ? Would he use one of those two paints, a cellulose paint, or what could he use for spraying, say, the walls of a room ?

MR. PETERS : Dealing with the second question, where you have to paint wet plaster, the finishing coats are the same, but the priming coats are different for plaster. The greatest danger with plaster is, first of all, is it wet, and are we going to get free lime and solids ? There are nitrolised celluloses for this type of plaster, but in our opinion before it can be attempted successfully to give a permanent result, it must be thoroughly dry. For nitro-cellulose there is a special plaster primer. With regard to lithopone it is always a ticklish subject where you are using this, and where possible we like to know the exact nature of the work the paint is going to be used for, and mix the three pigments in the proportions we think best.

MR. DIGGLE : I was rather interested in cellulose painting cast iron. Is it possible to get a fairly thick priming coat that will spread and fill the cracks ? If you leave any blemishes they show through the finished paint. Is it possible to get a thick undercoat that will smooth itself ? Secondly, you put anti-rust on bright

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steel parts to stop rust. Can you suggest anything whereby it sets hard like enamel, but will easily flake off?

MR. PETERS : With priming, the trouble is if you pigmentise your filler into the primer you are always tending to lose your adhesion with the primer. If you want to spray, why not, if you can stove, use the wet-on-wet process, or if your casting is rough, one coat of thermolax straight on? If you are going to try and heavily pigmentise your filler in cellulose, you are going to get trouble with adhesion. Where you want to put red on red, it is a good idea to get the undercoat as near finishing as possible.

MR. DIGGLE : We undercoat in one place and finish off in another. I was wondering if we could paint grey and finish off to the colour required in another shop.

MR. PETERS : If you are using a spray and you cannot get it hot, you are up against it. My advice is change your colour from red to a better colour, or coat it flat and give it eggshell finish.

MR. PETERS (SENIOR) : I do not think there is anything satisfactory for anti-rust paint for steel parts. You can procure lanoline in different forms, and it can be removed with a turpentine rag.

MR. WEBSTER : Can you tell me if it is possible to get a resin enamel which will stand 400 to 500°F. without discolouration?

MR. PETERS : The only one that will stand that temperature without change is aluminium thermolax. You will also get a slight change of colour, the lighter more pronounced.

MR. CARRICK : In dipping, is it necessary to recondition your bulk paints fairly often to keep up the standard? Would the paint have to be reconditioned after a certain period, or can you keep adding thinners and paint and keep the condition good?

MR. PETERS : It is not necessary, except occasionally to clean your tank, but paint and thinners must be added in the correct proportions as outlined by the makers.

MR. FARROW : I should like to know whether aluminium thermolax is satisfactory on motor-car exhaust manifolds, and also whether it is a fact that cellulose finishes now used on motor-cars are softer than when first introduced?

MR. PETERS (SENIOR) : I would like to reply to the last part of that question if I might. You are going a long way back. When they used to tell you that you could strike a match on a motor car it was all bunkum.

MR. PETERS : With regard to the first part of the question, if you can get the casting clean, the answer is yes.

MR. PARRISH : In my experience with cellulose, I find if you put new cellulose on top of the old, you get what is called "spider webbing." Can you tell me the cause?

MR. PETERS : If the old cellulose is in good condition and not perished and well cleaned down, we have very little trouble with

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that. We have found it due to the cellulose thinners in the new lacquer attacking the underneath cellulose.

MR. PARRISH : If you have a panel which you want to touch up, you get a certain amount of dust all round.

MR. PETERS : One method we suggest is to put thinners in your cellulose and spray as quickly as you can over the whole panel.

MR. PARRISH : Is there any way of stopping "orange peeling" when spraying cellulose ?

MR. PETERS : There is really no way of stopping "orange peeling." The best way to eliminate it is to make quite sure of your materials, and the adjustment of your spray. Also the sprayer must be expert. One man will often get more "orange peeling" than another.

MR. PARRISH : What would you do when you have an old oil finish and you want to spray cellulose on to it ?

MR. PETERS : We often use cellulose thinners when we want to clean cellulose quickly. If you have got an oil finish or painted surface, clean down in the ordinary way, spray on a buffer coat, allow to dry overnight, and go on with your cellulosing.

MR. AYTON : I have listened with much interest to this paper. Mr. Peters has dealt with a most important subject as the prevention of corrosion is a serious problem for the engineer. The amount of steel in the world which is exposed to corrosive conditions is enormous. I remember reading a paper by Sir Robert Hadfield in which he touched on this subject, and he gave an estimate of what he thought was the annual wastage of steel in the world through corrosion, and if I remember rightly he estimated it at 25,000 tons. Put into pounds, shillings, and pence, it represents a serious wastage, and anything that can be done with paint work to prevent that wastage is very desirable. We have in the last few years witnessed enormous developments in the matter of resisting corrosion. The steel maker has produced steel with the characteristics of corrosion resistance developed to an important degree, as for example, copper steel. We have also got stainless steel, which unfortunately is too expensive at the present time to use largely for constructional purposes, so we have to rely still on the paint manufacturer to supply us with the means of resisting corrosion, or at least putting off the day when corrosion appears, as long as possible, and Mr. Peters has given us a good deal of useful information on this subject. He has also given us some interesting matter in connection with one of our modern industries, viz., motor-car finish. We owe him a very great debt for coming all the way from Birmingham, and I have pleasure in proposing a very hearty vote of thanks to Mr. Peters for his paper.

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Objects of the Institution.

Among the objects for which the Institution is established are :—

“ (a) To promote the science and practice of production engineering ; and for that purpose to carry out any of the following objects :

“ (b) To hold meetings of the Institution for reading and discussing communications bearing upon the said science and practice, or the application thereof, or upon subjects relating thereto.

“ (c) To enable engineers to correspond, and to facilitate the interchange of ideas respecting improvements in the various branches of the practice of production engineering, and the publication and communications of information on such subjects to members of the Institution and others.

“ (d) To establish scholarships, organise lectures, hold examinations, to grant premiums and prizes for papers and essays, and by any other similar means to enlarge the knowledge and improve the practice of production engineering.”

Qualifications for Graduateship.

As defined in the Articles of Association the qualifications for Graduateship are :—

“ Graduates shall be persons, not under twenty-one years of age, who can show evidence that they are receiving practical training in production engineering, and who have passed an examination prescribed from time to time by the Council, or who otherwise satisfy the Council that there are special circumstances which, in the opinion of the Council, entitle them to admission.

“ Graduates may not continue as such if they cease to follow the professional calling of production engineering, nor in any case beyond the age of thirty ; they may, however, between the ages of twenty-eight and thirty be transferred, on application, at the discretion of the Council, to the class of Associate Members.

“ Candidates for admission as Graduates who have passed the aforementioned examination but who have not yet attained the age of twenty-one, may attend the meetings and receive the publications of the Institution without charge, but shall not be entitled to vote at meetings or be entered in the Register of Members ; but on attaining the age of twenty-one they may apply to be admitted

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as Graduates, and upon being so admitted shall have their names entered on the Register and become Members of the Institution.

"No person shall be elected a Graduate after the completion of his twenty-ninth year."

The Annual Subscription for each Graduate is £1 up to twenty-five years of age, and £1 10s. between twenty-five and thirty. On admission to the Institution Graduates may be required to pay an entrance fee, the amount of which shall be determined by the Council from time to time. At present, and until further notice, no entrance fee is charged.

Sir H. Austin Prize and Free Graduateships.

In addition to the Sir Herbert Austin Prize awarded to the candidate of highest attainments, the Council of the Institution will award Free Graduateships up to twenty-five years of age each year to those eligible candidates who attain the five highest places in the Examination.

Examination Conditions.

Examinations will be held each year on the Friday and Saturday following Easter Sunday, in London, Glasgow, Birmingham, Manchester, and Bristol, and also at any approved University, Technical Institution or Works School elsewhere as may be required. Where less than five candidates enter at any centre for the examination, a local fee, additional to the ordinary examination fee of 10/-, may be charged.

Candidates are required to fill up the prescribed Form of Application for admission (which can be obtained on request from the Head Office of the Institution, or from the Hon. Secretary of any Section of the Institution) and to send the form, together with the examination fee of 10/- to the General Secretary not later than 31st January. Where permission to sit for the examination is not given, the examination fee will be returned.

The examination will be divided into five sections. Work on the first section—an Essay—will be performed at home and must be submitted by the date which will be announced, whilst the remaining sections will be covered at an examination centre.

The examination will be of six hours' duration each day with an interval of one hour and a half from 1-0 to 2-30 p.m., but candidates must present themselves not later than 9-45 a.m., at the place of examination on the Friday morning.

Candidates must provide themselves with drawing instruments, scales, and set squares at examinations during which they may be required. Four-figure Logarithmic Tables and squared paper will be provided by the Institution. No other books or instruments

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may be carried into the examination room. Slide Rule calculations will be accepted throughout.

The list of successful candidates will be printed and posted to each candidate between one and two months after the examination. No other examination certificate will be issued.

SYLLABUS.

The following Syllabus for the various sections of the examination is given to indicate the lines of study recommended to candidates, and is not intended to limit their interests but to direct them in desirable lines.

A general knowledge of the subjects is expected and the questions should not be beyond the capabilities of those who have taken an inquiring interest in their chosen profession, although their experience is of necessity limited.

The Papers of the Graduateship Examination are intended to test the candidate in those special branches which are of peculiar importance in Production Engineering. In evaluating the candidate's work, the examiners will be guided rather by the practical knowledge and interest shown than by an academic reproduction of text-book information.

The Council of the Institution feel that although one of the major problems of Production Engineering is that of the human factor involved in the relation between Capital, Management, and Labour, too little attention has been given to this important subject in the Curriculae of Technical Schools. In certain Papers, therefore, some questions will be framed not only to reveal the candidates' attitude towards their fellow-workmen, but to discover their mental attitude towards Industry in general and Production Engineering in particular.

Essay.

Candidates whose Application Form has been accepted will be required to submit an Essay of from 1,000 to 1,500 words on a Production Subject, within four weeks of the despatch of such notification. A list of Subjects will be supplied. Works of reference may be consulted by candidates, *the titles of such works should be stated*. The Essay must be accompanied by a Declaration that, subject to the consultation of works of reference, it is the unaided work of the candidate.

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FIRST DAY.

Section A.

ONE only of the three following subjects is required to be taken :—

- (1) **Construction of Machine Tools and Jig and Tool Design.**

Time 3 hours (10.0 a.m. to 1.0 p.m.).

Machine Construction.

Knowledge of construction of standard and well-known special machine tools, including typical constructions for wear adjustments, convenience of controls, disposal of swarf, protection of parts from swarf and dirt, ease of cleaning and lubrication, feed mechanisms, and capacity of machines.

Ability to make sketches illustrating details of construction and to show, by written descriptions aided by sketches, an intimate knowledge of how the machines and their parts function.

Geometry and calculations relating to simple mechanisms and jigs.

The principles of alignment tests for spindles, slides, and other machine tool elements.

Layout of radial and axial cams and former bars.

Capacity of clutches and power transmission elements.

Selection, Installation, and Maintenance.

Selection of standard and special machine tools for required operations.

Methods of testing the alignment and accuracy of machine tools, acceptance tests, including production times.

Methods of supporting, fixing, and levelling of machine tools. Design of foundations where necessary. Layout of machine tools for required sequence of operations.

Care and maintenance : Cleaning, lubricating, overhauling, and adjusting for wear ; belting, belt striking and other control gears ; coolants and cooling systems ; compressed air auxiliary services.

Tools and Equipment, Jigs and Fixtures.

Cutting tools, their shapes and angles for different cutting tools and the materials to be cut, variation with type of operation ; turning, planing, drilling, boring ; drilling tools and boring bars, reaming tools, pilot reamers, broaches. Holding and support of work and tools, tool holders.

Design and construction of jigs and fixtures, fabrication by welding, methods of work location and clamping, jig boring to accurate dimensions and testing of jigs, bushes.

British standard and other small tools and cutters.

(2) Physical Metallurgy and Treatment of Metals.

Time 3 hours (10.0 a.m. to 1.0 p.m.)

Cast Iron and Steel.

Pig iron and the production of : (a) common grey iron castings ; (b) malleable iron castings ; (c) wrought iron ; (d) steel by the various processes. Composition and general properties of those and of the principal steels used in engineering. Effect of alloying elements in steel and the selection of steel for the special properties required. Machinability.

Non-Ferrous Metals and Alloys.

General properties and uses of the principal non-ferrous metals and their alloys, brasses, bronzes, aluminium and magnesium alloys, bearing metals, and solders.

Primary Forming Processes.

General description of Foundry Practice, common methods of moulding and procedure in casting as applied to cast iron, steel castings, and non-ferrous metals. Special foundry methods, such as die-casting, centrifugal casting. Methods for quantity production. Cold and hot working of ferrous and non-ferrous metals. Fabrication by welding, acetylene and electric welding, rods and fluxes used, tests of welds.

Heat and Heat Treatment.

Methods of measuring furnace temperatures. Types of furnaces employed and their applications. Normalising, annealing, quenching, tempering, case-hardening. Critical thermal points and their determination, application to heat treatment of steels and non-ferrous metals. Heat treatment of large forgings and castings. Heat treatment of non-ferrous metals.

Structure of Metals

Use of microscope in examining structure, relation of structure to mechanical properties, recognition of various constituents in iron and steel and the simple non-ferrous metals. Effect on structure and properties of hot and cold working and heat treatment.

Testing of Materials.

Tensile, compression, torsion, and impact tests. Cupping tests. Various hardness tests, scleroscope, Brinell, Vickers, and Rockwell. Tests for work hardening. Effects of high temperature on strength and other properties.* Hot hardness of carbon and high-speed tool steels.

Cutting Tools.

Special properties required in cutting tools, the various tool steels, composition and treatment, special alloy cutting tool.

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(3) The Application of Electricity to Production.

Time 3 hours (10-0 a.m. to 1-0 p.m.).

(Note.—It is expected that candidates will have some knowledge of the underlying principles before embarking on the following course).

General characteristics of D.C. shunt and series motor and A.C. induction motors; Starting torques and stalling torques; Methods of starting and speed control. Losses in Electrical machinery: losses in efficiency and H.P. equivalent. Electric motor drive: choice of motor; Individual and group drives. Economics of electrical drives.

Illumination: Candle power: Mean spherical candle power; lumen output; foot-candle. Electric lamp efficiencies; Electric lighting system efficiencies. Types of reflector used. Spacing-height ratios: Utilisation Factor; Electric lamp economics: Effect of increased illumination on work output.

Electric Furnaces: Types of furnace; advantages of electric furnaces: Temperature measurement and control.

Electric Welding. Arc welding with bare and covered electrodes: A.C. and D.C. arc welding layouts. Resistance welding. Electro-deposition of metals—description of process and equipments.

Electrical Tariffs. Reasons for various tariffs explained. Effect of demand, diversity and load factors on Electrical Power economics.

Effect of Power Factor. Methods of P.F. improvement.

Home Office Electricity Regulations: The more important of these should be known.

Section B.

Workshop Practice and Processes.

Time 3 hours (2-30 p.m. to 5-30 p.m.).

Workshop Drawings. Correctly dimensioned free-hand sketches.

Modification of designs of simple articles to facilitate production.

Limit Systems, Gauges and Gauging.

Machine Tools and their uses.

The design of cutting edges.

Feeds and Speeds.

The planning and sequence of operations.

The influence of quantities upon methods of production.

Applications of Jigs and Tools.

Simple applications of Metallurgy and Heat Treatment to Workshop Processes.

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SECOND DAY.

Section C.

Factory Organisation.

Time 3 hours (10.0 a.m. to 1.0 p.m.).

Works Sites.

Suitability of land for buildings and layout.

Transport facilities.

Power supplies.

Local government bye laws, rating conditions.

Buildings and Plant.

General layout as determined by nature of work.

Flow of material, arrangement of shops to suit sequence of operations.

Internal transport.

Lighting, heating, ventilation, and sanitation.

Electric power, gas, compressed air.

Equipment.

Consideration of plant according to product, variation in type depending on quantity. Lifting and transporting equipment.

Management.

Evolution of industrial management, principles of scientific management.

Types of factory organisation, organisation charts.

Factors necessary for co-ordination of office and works.

Elimination of waste.

Home Office regulations.

Workmen's Compensation Acts.

Staff.

Labour Bureau and selection of operatives.

Schemes of training for youths and apprentices.

Comparisons of various systems of remuneration, day, piece, bonus, profit sharing.

Design, Inspection, and Research.

Drawing Office organisation, specifications, component and assembly lists. Manufacturing and inspection standards, tolerance and limits, inspection at various stages, handling of rejects. British Standards, internal factory standards. Research and experimental departments.

Section D.

Planning, Storekeeping, and Costing.

Time 3 hours (2.30 p.m. to 5.30 p.m.).

Production planning.

Organisation of a planning department, manufacturing programmes. Layout of operations, job, batch, and repetition work.

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Tool layouts and capacities of machine tools, power absorbed, feeds and speeds.

Economic use of jig and fixtures.

Time and motion study, rate fixing. Work labels, job tickets, time sheets, layout cards.

Tool room and tool room machines, tool stores, issue of tools and jigs.

Care, checking, and maintenance of gauges.

Production Control.

Functions of progress department, maintenance of supplies, maintaining schedule programmes, progress charts and indicators.

Purchase.

Materials control and stores. Market forms of metals, alloys, and other materials : Costs, specifications. Routine of issue of order and receipt of goods, checking specification and quality. Maximum and minimum stocks, price curves. Layout of stores, store keeping systems, records.

Costing.

Prime costs, wages and materials. Depreciation. Oncosts and overheads and their allocation. Record of costs. Methods of time recording. Estimating production times, costs of labour and machine charges. Calculation of weights. Preparation of quantities and estimates for a quotation. Charts and graphs.

Forms of Application.

Intending candidates should apply to the General Secretary to the Institution, or to the Hon. Secretary to any Section of the Institution, for the necessary Entry Forms.

Exemption from Examination.

Candidates who have passed Section C of the Associate Membership Examination of the Institution of Mechanical Engineers, together with "The Fundamentals of Industrial Administration" in Part 2, Section A, of the same examination, or any approved examination of equal standard, will be exempt from this examination.

Copies of Examination Papers.

Copies of the latest available Examination Papers can be obtained, price 3d. per set, on application to the General Secretary, **The Institution of Production Engineers, British Industries House, Marble Arch, London, W.1.**

**PAPERS SET AT THE GRADUATESHIP
EXAMINATION, APRIL, 1935.**

NOTE.—Candidates were required to answer only one of the three following Papers : Construction of Machine Tools and Jig and Tool Design ; Physical Metallurgy and the Treatment of Metals ; The Application of Electricity to Production. All the other Papers had to be answered.

**CONSTRUCTION OF MACHINE TOOLS AND JIG AND TOOL
DESIGN.**

FRIDAY, 26TH APRIL, 1935. (10-0 A.M.—1-0 P.M.)

Examiner : J. LOXHAM, M.I.P.E.

One question from each Section must be attempted, also one additional question selected from any of the three Sections.

SECTION A.

1. Illustrate by sketches any two of the following features of machine tool construction :

- (a) Hollow lathe spindle with plain parallel bearings and fitted with a ball-bearing thrust race.
- (b) Centralised control as fitted to a modern horizontal milling machine.
- (c) The construction of the hand-feed mechanism and balance of a high-speed sensitive drilling machine.
- (d) The traversing mechanism on the apron of a centre lathe.
- (e) A capacity chart for a turret lathe.
- (f) Two methods of protecting the bearing surfaces of machine tools from abrasive action due to swarf.

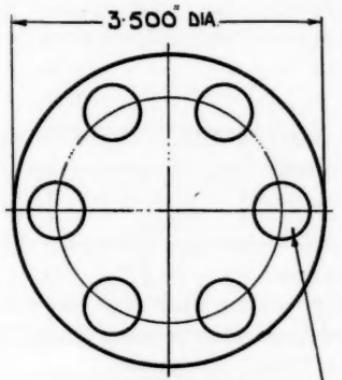
(27 marks)

2. Re-draw the sketch and dimension it in a manner suitable for jig boring. (19 marks)

GRADUATESHIP EXAMINATION, 1935

3. Describe briefly how you would thoroughly test the accuracy of either

- (a) A plain horizontal milling machine; or
(b) A tool room centre lathe. (19 marks)



Section A, Question 2

SECTION B.

1. Describe how you would test under working conditions at the makers' works one of the following machine tools prior to accepting delivery.

- (a) A large double-action press.
(b) A combination turret lathe.
(c) An eight foot radial drill.
(d) A plain cylindrical grinder. (27 marks)

2. Describe how you would instal one of the machines referred to in question 1. (19 marks)

3. Describe how you would ensure that the line shafting, counter-shafts, bolts, and machines in a small factory of 75 machines were kept in a safe and efficient working condition. (19 marks)

SECTION C.

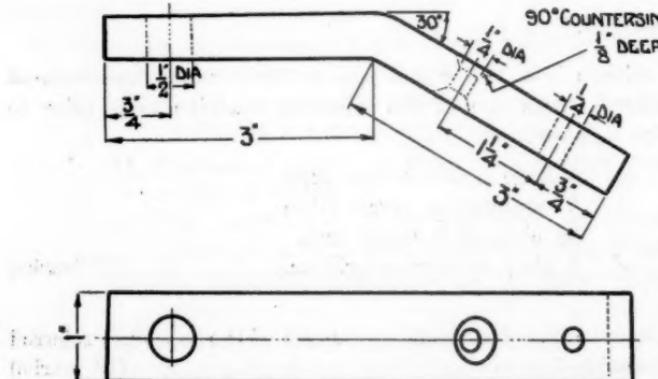
1. Prepare an operation layout describing the method of manufacture of *one* only of the following parts shown in Figures 1 and 2, in regular monthly batches of 100.

Indicate the operations where you consider jigs are necessary and make simple sketches of the type of jigs you would recommend.

(27 marks)

2. Make careful sketches of three of the following cutting tools and add brief notes describing the precautions to be taken when using them.

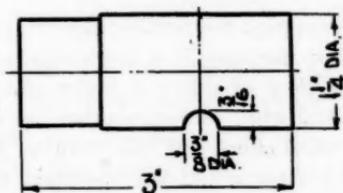
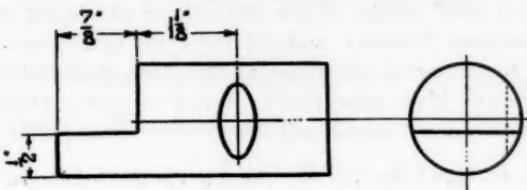
- (a) Tungsten carbide tipped tool for the finish machining of cast iron.
- (b) Slotting tool for machining cast iron.
- (c) Piloted boring bar for machining mild steel stamping with a blade type cutter.
- (d) Expanding reamer for use on turret lathe.
- (e) Core drill for machining cast iron.
- (f) Screw cutting tool for square thread. (19 marks)



ROUGH MATERIAL $\frac{1}{2} \times 1$ BLACK ROLLED MILD STEEL.

Section C, Question 1, Fig. 1.

GRADUATESHIP EXAMINATION, 1935.



ROUGH MATERIAL $\frac{1}{2}$ DIA. BRIGHT DRAWN MILD STEEL.

Section C, Question 1, Fig. 2.

PHYSICAL METALLURGY AND TREATMENT OF METALS.

FRIDAY, 26TH APRIL, 1935. (10-0 A.M.—1-0 P.M.)

Examiner : A. BRAMLEY, D.Sc. (LOND.), A.R.C.Sc., F.I.C.

Answer SEVEN questions only.

- What is pig-iron ? State briefly the composition of pig-iron. How is pig-iron graded and on what factors does the appearance of the fracture of pig-iron depend ? What kind of pig-iron would you use for the production of : (a) grey iron castings ; (b) malleable iron castings ? Give full reasons for your choice.
- How is wrought iron produced ? What tests would you apply in order to ascertain whether a certain bar was made of wrought iron or mild steel ? State carefully the results of the tests for both metals.

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3. Give a brief outline of the methods of producing steel by :
(a) the Bessemer Process ; and (b) the open hearth process. Is there any fundamental difference in the steel produced by these two processes ? If so, what is it ? What do you understand by "acid" and "basic" steels and which would you prefer ?
4. Describe carefully any one reliable method of measuring the temperature of a furnace working up to about 1,000°C. Also describe any one form of high temperature recording instrument.
5. How would you determine the recalescence temperature of a piece of steel ? For what purposes is a knowledge of this point useful ? If, in the production of ship's or boiler plates, the final rolling is done on the metal when its temperature has fallen below the recalescence point, what effect will this have on the physical properties of the metal ? How would you ascertain whether this final rolling of a piece of steel plate had been done at a temperature above or below the recalescence point ?
6. Describe carefully how you would prepare the specimens and carry out any *two* of the following tests :—
 - (a) Tensile tests so as to obtain all the usual data.
Sketch a typical load/extension diagram for a mild steel.
 - (b) Impact test.
 - (c) Hardness test.
 - (d) Torsion test.
7. Describe briefly a metallurgical microscope mentioning especially the method of illumination. How would you prepare a specimen for examination under a microscope ? Indicate by sketches the appearance, as seen under the microscope, of any three characteristic structures stating the approximate magnification.
8. Write a short essay on the various methods of preventing corrosion, describing the way by which each method accomplishes its object.
9. Give a short account of the composition, properties, and uses of any *one* of the following : (a) brass ; (b) bronze ; (c) white metal.
10. What effects are produced by the addition of nickel and chromium, separately and together to steel ?

GRADUATESHIP EXAMINATION, 1935

THE APPLICATION OF ELECTRICITY TO PRODUCTION.

FRIDAY, 26TH APRIL, 1935. (10.0 A.M.—1.0 P.M.)

Examiner : C. F. PARTRIDGE, B.Sc. (ENG.), M.I.E.E.

Answer FIVE questions only.

1. Discuss the relative merits of gas, oil, and electricity for heating any type of furnace with which you are familiar.

2. Criticise the undermentioned from the standpoint of the "Home Office Regulations":

(a) Portable handlamp with wire guard for use in a workshop with concrete floor; the lamp is fed through ordinary two-core flexible cable.

(b) A lampholder of the screw socket type unprovided with an insulating shroud and controlled by a single pole tumbler switch connected in the "earthing" main.

(c) A 15 h.p. 400-volt 3-phase squirrel-cage induction motor controlled by a 15-amp. 250-volt triple pole airbreak switch fuse located on a wall 30 feet from the machine.

The frame of the motor is connected to a stanchion forming part of the main steel structure of the building.

3. Assuming a 400-volt 50-cycle supply detail the necessary electrical apparatus required for either

(a) A supply of 1,500 amperes at six volts for electrolytic work; or

(b) A supply for a one-operator electric arc welding set using covered electrodes up to No. 8 gauge.

4. Answer either (a) or (b).

(a) A workshop with a floor area of 4,000 square feet is to be illuminated to an average intensity of five

THE INSTITUTION OF PRODUCTION ENGINEERS

foot-candles. Assuming a utilization factor of 0.5, calculate the total lumens required and describe any instrument you could use to check the result obtained.

- (b) What are the main requirements for an efficient lighting scheme ?

5. Answer either (a) or (b).

- (a) What are the disadvantages from an Electricity Supply Company's standpoint of a low power factor load ?
- (b) A factory takes 200 K.V.A. at an average power factor of 0.8. Estimate the leading K.V.A. required to raise the power factor to 0.95 and describe any one method of achieving this result.

6. Compare the torque-speed characteristics of shunt and series motors.

For what industrial applications are series motors used ?

Indicate the main constructional features of either (a) or (b).

- (a) A motor with series characteristics to work on a direct current supply.
- (b) A motor with shunt characteristics to work on an alternating current supply.

7. Answer either (a) or (b).

- (a) Compare the various methods used for starting multiphase induction motors.
- (b) Sketch and describe a face-plate starter for a 10 h.p. D.C. shunt motor.

8. Answer either (a) or (b).

- (a) The supply to a factory is alternating current at 50 cycles per second. In one department a range of two h.p. motors with shunt characteristics is required. The motors must have at no load a speed of approximately 6,000 r.p.m. Indicate with technical data any one method of meeting this demand.
- (b) Discuss the advantages and disadvantages of individual electric drive.

GRADUATESHIP EXAMINATION, 1935

WORKSHOP PRACTICE AND PROCESSES.

FRIDAY, 26TH APRIL, 1935. (2.30 P.M.—5.30 P.M.)

Examiner :

J. LOXHAM, M.I.P.E.

Answer FOUR questions only.

1. Make an arrangement and dimensioned detail sketches of all the parts constituting either

- (a) The tumbler gear of a lathe.
- (b) A pillar type tool box for a shaping machine.
- (c) A milling machine arbor and draw bolt.

2. (a) Define the following terms :—Tolerance, allowance, maximum allowance, minimum allowance, shaft basis limit system, hole basis limit system, unilateral basis limit system, bilateral basis limit system.

(b) Describe either the Newall limit system or the British Standards Institution limit system.

3. Describe by means of an outline diagram, the mechanism of a dividing head when set for :

- (a) Simple dividing.
- (b) Spiral milling.

OR Describe by means of a simple tool layout drawing, the method you would adopt for machining the part shown in the sketch by two of the following methods :

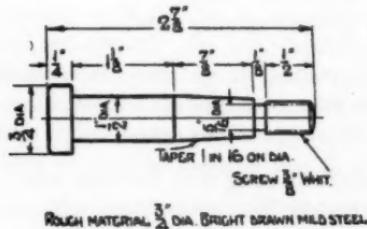
- (a) On a centre lathe.
- (b) On a capstan lathe.
- (c) On a multi-spindle auto.

4. Describe by means of sketches, the characteristic features of six of the following tools giving the angle or equivalent angle of top rake and the angle of clearance :

- (a) A plain planing tool for cast iron.
- (b) A twist drill.
- (c) Number 8, 10P gear cutter.

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- (d) Slotting cutter for use on milling machines.
 - (e) Circular form tool.
 - (f) Bar-turning tool for use on turret lathe.
 - (g) Fellow's gear shaper cutter.
 - (h) Broach for cutting standard key ways.
 - (i) Modern cylindrical milling cutter 25° spiral angle.
5. Plan the manufacturing operations for either a cast iron automobile piston (approx. 2" dia.) or a good quality $\frac{1}{2}'' \times \frac{1}{2}''$ steel spanner, assuming a production of
- (a) Two only.
 - (b) Batch orders of 50 at intervals of approximately two months.
 - (c) Continuous production, output approximately 1,000 per week.
- Indicate at the head of each layout, the form of the rough material and against each operation, state whether you would recommend special jigs or tools, and if so, their approximate cost.
6. (a) Describe in detail how you would
- (1) Harden a turning tool made from high-speed steel.
 - (2) Harden and temper a milling cutter made from cast steel.
 - (3) Case-harden a mild steel part, thickness of case, $\frac{1}{8}$ ", and core to be as tough as possible.
- (b) Describe the principles under which two distinct methods of temperature measurement operate. (Range of temperature, 200°C. to 1,000°C.).



Question No. 3.

GRADUATESHIP EXAMINATION, 1935

FACTORY ORGANISATION.

SATURDAY, 27TH APRIL, 1935. (10-0 A.M.—1-0 P.M.)

Examiner :

J. FRANCE, A.M.I.P.E., A.M.I.MECH.E.

Answer FIVE questions only.

The marks obtainable for each question are stated.

1. Assuming that as the head of the Labour Bureau of an engineering concern you had to interview candidates for the following vacancies, what qualities and qualifications would you look for in the individuals applying for the various posts ?

- (a) A machine operator for easy repetition work ;
- (b) A toolmaker ;
- (c) A storekeeper ;
- (d) A draughtsman ;
- (e) A foreman for a highly-organised repetition shop ;
- (f) A toolroom foreman. (25)

2. A workshop, incorporating all necessary accommodation for male and female labour, requires to be erected on a given vacant site.

Enumerate the items subsidiary to the actual shop building which must be included.

State the steps necessary to be taken before and during erection to obtain the approval of : an Insurance Company ; the Local Government Authorities ; and the Home Office. (20)

3. A certain machine is built in large quantities from : cast, forged, pressed, welded, and machined details. The weight of raw material purchased per machine is greatly in excess of the weight of a finished machine.

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State where waste of material is likely to occur and suggest ways and means of reducing it. (20)

4. Do you consider it the best form of organisation to have like machines grouped together or to arrange lines of mixed machines along which components can flow from the rough to the finished stores ? Give reasons for your answer. (20)

5. Trace the evolution of Industrial Management, discussing the merits and demerits of each phase.

What do you understand by the term " Scientific Management " ? Is such management applicable only to the engineering industry ? (15)

6. Under the Halsey Weir Premium Bonus scheme of wage payment the worker receives only a fraction of the value of the time he saves, whereas under Taylor's Differential Rate method he receives more than he saves.

Describe the two schemes and contrast their methods. (15)

7. Choosing your own examples, state the type of internal works transport which you consider most suitable for handling :—

- (a) Very small parts made in large quantities ;
- (b) Medium-sized parts made in moderate quantities ;
- (c) Heavy parts made in small quantities. (15)

8. State your views on the following inspection matters :—

- (a) Are coarse or fine limits best ?
- (b) Should every component made be inspected ?
- (c) Is inspection after each operation advisable ?
- (d) Should the producer be his own inspector ? (15)

GRADUATESHIP EXAMINATION, 1935

PLANNING, STOREKEEPING, AND COSTING.

SATURDAY, 27TH APRIL, 1935. (2.30 P.M.—5.30 P.M.)

Examiner : J. FRANCE, A.M.I.P.E., A.M.I.MECH.E.

Answer FIVE questions only.

The marks obtainable for each question are stated.

1. A jig, as designed, consisted of a cast-iron body, forged steel clamps and case-hardened mild steel bushes, together with various standard bolts, screws, and nuts.

Its manufacture had not commenced and no pattern had been made when it became essential that the jig be completed within a few hours. Suggest modifications to the specification which although slightly increasing the cost of the jig would not diminish its efficiency and yet enable it to be made very quickly. (25)

2. Explain with reference to an example the "Machine Hour Rate" method of apportioning oncosts.

Show how this system can be used to detect whether high-rated machines or others have had most idle time during a particular costing period.

How can machine idleness conveniently be allowed for when allocating oncosts ? (20)

3. A company secures an order which involves the use of large quantities of brass. The contract is to be completed in six months and equal amounts of metal will be required each month during progress.

As the person responsible for buying this material, state :—

- (a) The procedure to be adopted before ordering ;
- (b) If the lowest price offered should be accepted ;

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- (c) If you would buy from one supplier only, should several offer similar terms and quality ;
(d) Should the whole of the material required be purchased at once or in instalments ? (20)

4. Estimate the prime cost of producing 1,000 mild steel bushes of $2\frac{1}{2}$ inches overall length ; 1 inch diameter bore ; $1\frac{1}{2}$ inches outside diameter ; with a head 2 inches diameter, $\frac{1}{4}$ inch thick ; all dimensions to limit $\pm .005$ inch. A high finish is not necessary.

Assume that wages are 15d. per hour, and mild steel costs £15 per ton. Tool costs can be ignored. (20)

5. Outline a scheme of control whereby production can be synchronised with delivery promises. (15)

6. Discuss "Depreciation" from three different viewpoints.

Constant attention to repairs can keep a machine in service indefinitely ; how would you allow for this fact when assessing depreciation ? (15)

7. What records of machine tools do you consider a plant engineer should keep to enable him to allocate to new work machines of suitable capacity ?

Choose any four different types of machine tools with which to illustrate your answer. (15)

8. Describe the "Perpetual Inventory" system of stores records and explain its operation. Sketch a suitable layout of a bin or index card which might be used.

Discuss the advantages claimed for this method over others. (15)

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